UNITED STATES DEPARTMENT OF AGRICULTURE
Foreign Agricultural Service

Washington, D. C.
June 1, 1960

International Animal Feed Symposium

TECHNOLOGICAL ADVANCES IN LIVESTOCK FEEDING IN THE UNITED KINGDOM*

Our terms of reference are very wide and cover a variety of topics, on some of which we are not qualified to speak with competence from first-hand knowledge. In particular, no statement of ours should be implied to represent the views of the feedstuffs industry.

FEED MANUFACTURING

In the United Kingdom the feedstuffs manufacturing industry falls under 3 main headings :

(1) Small provender millers.—These are processors of straight grains such as barley, oats, feed wheat or maize and the various processes include cutting, kibbling, gritting, flaking and grinding into meals. Some small provender millers may manufacture simple feed mixtures from either whole or processed grain and some have, in recent decades, developed into country compounders.

(2) Compound manufacturers.—If the term "compound" is taken to mean a feed mixture balanced for a particular purpose, there are 2 main classes of compounders—the port compounders and the country compounders. The port

*This is a report prepared by A. Eden, Nutrition Chemist, (British) National Agricultural Advisory Service, S. K. Kon, National Institute for Research in Dairying, Shinfield, Reading, England, and I. A. M. Lucas, Rowett Research Institute, Bucksburn, Aberdeen, Scotland, and presented at the International Animal Feed Symposium sponsored by the U. S. Department of Agricultute and the Soybean Council of America, Inc. in Washington, D. C. May 4-6, 1959. The Foreign Agricultural Service is reproducing this and similar Symposium reports as a service to those interested in animal feeding and feed utilization.

compounders are mainly large organizations primarily concerned with oilseed crushing or flour milling, and some of them have been compounding since the early years of the century. The country compounders are mainly smaller businesses developed by agricultural merchants and country millers, many of them having taken up compounding in the last 2 or 3 decades. A large proportion of the port compounders' products is now sold cubed or pelleted, and an increasing proportion of the country compounders' output is also in this form.

(3) **Balancer manufacturers.**—To avoid confusion with the more general use of the term "concentrate" to describe any non-bulky feed commonly used in the United Kingdom, the term "balancer" is used here instead of the term "concentrate", sometimes applied by the trade in this context.

Balancer manufacturers are concerned principally with the production of blended mixtures of protein foods (both animal and vegetable), minerals (including trace elements), vitamins, and for particular purposes various additives, such as antibiotics and coccidiostats. Such mixtures are sold for blending in simple proportions with cereals and cereal byproducts to produce balanced rations for all classes of livestock. The products may be sold direct to farmers or country compounders who lack the technical knowledge and efficiency of the larger compound manufacturers.

Before the outbreak of war in 1939 more than half of the feedstuffs purchased by farmers was in the form of "straights" (single products). With the war a scheme of rationing feedstufis was introduced and continued into the postwar years until July 1953. It undoubtedly influenced the pattern of demand, since the cereal and protein ration documents were often issued to the farmer and compounder for the particular classes of stock in the same ratio as the cereals and protein feeds in the more popular compounds. By the time controls ended in 1953, farmers had become accustomed to the purchase of compound feedstuffs. Indeed, today there are very few provender millers (large or small) who are not also compound manufacturers. Over this period the compound manufacturers developed an increasing awareness of their responsibilities in livestock feeding, and they became much more interested in scientific and nutritional advances and in nutritional improvement of their products. It all resulted in increased benefits to the farmer and his livestock, with the result that today the compound feedstuffs industry is a highly technical and scientific organization.

In 1939 the total production of compound feedstuffs in Great Britain was a little more than 4 million long tons, with a small additional tonnage manufactured in Northern Ireland. Compounds, as such, represented about 45 percent of the total purchased feedstuffs passing through normal trade channels. The severe rationing program of the war years when supplies, apart from protein feeds,

consisted mainly of home-produced feedstuffs caused a drop in compound production to below 2 million long tons a year.

With the end of the war in 1945 imports increased and rationing scales were progressively raised year by year until in July 1953 rationing ended. In 1953 over 5 million long tons of compounds were produced in Great Britain. The preference of farmers for purchased compounds did not decrease with decontrol, and in each year, apart from a slight set-back in 1957, compounders have increased their manufactures so that in 1958 total production in Great Britain amounted to nearly 7.2 million long tons. These figures do not include the production of compounds in Northern Ireland for which accurate figures are not normally available, but it is estimated that compound production there has now reached 600,000 long tons annually. The figure for the United Kingdom (Great Britain and Northern Ireland) of about 7.8 million long tons of compounds represents about 70 percent of the total tonnage of purchased feedstuffs passing through normal trade channels. It should be borne in mind that, apart from compounds flowing through these channels, many large farmers make their own compounds often from home-produced feeds. Some farmers have fully mechanized processing including cubing and pelleting.

There are about 1,200 compound mills in Great Britain and, although over 1,000 of these are situated in inland towns and districts, the bulk of the compound production is in the hands of compounders situated in the main ports of England, Wales and Scotland. Indeed the port compounders account for over 70 percent of the total compounds produced annually.

The prosperity of the compound industry is closely linked with a thriving and prosperous agricultural industry. There is also a close connection with the flour-milling and seed-crushing industries from which the compounders obtain much of their supplies of raw materials in the form of oilcakes and meals and wheat byproducts. The sources of raw materials used in compounds and the use of home-grown cereals and home-produced materials in compounds are discussed below.

The manufacture of protein-mineral-vitamin balancers was on a very small scale in prewar years, but since decontrol in 1953 their production, in common with compound production, has steadily expanded. No official returns are required from manufacturers on balancers, but it is estimated that the total annual production at present is over 200,000 long tons. They are very popular with both the country compounder and the farmer who mixes his own rations, for it is a comparatively simple matter to blend units of balancers with a recommended number of units of cereals and cereal byproducts.

DETAILS OF COMPOUND PRODUCTION IN GREAT BRITAIN

Year	*Cattle food* 1,000 long tons	*Calf food* 1,000 long tons	*Pig food* 1,000 long tons	*Poultry food* 1,000 long tons	*Horse and sheep food* 1,000 long tons	*Others* 1,000 long tons	*Total* 1,000 long tons
1938-39	1	1	1	1	134.8	—	4024.1
1945	1080.9	87.2	259.8	552.3	24.3	—	2004.5
1946	1134.8	88.8	281.3	597.3	28.4	—	2130.6
1947	1220.7	114.0	256.9	583.8	36.5	—	2211.9
1948	1387.3	139.1	470.7	846.7	30.2	—	2874.0
1949	1550.4	154.0	620.4	1002.6	23.3	—	3350.7
1950	1848.6	157.6	800.9	1309.1	16.4	25.9	4158.5
1951	1522.9	122.5	1194.2	1439.5	13.8	16.7	4309.6
1952	1382.8	116.0	1470.6	1465.3	12.3	18.7	4465.7
1953	1665.0	159.1	1567.2	1731.2	12.3	31.6	5166.4
1954	2071.9	203.8	1751.4	1806.0	20.3	83.1	5936.5
1955	2294.8	203.2	1778.0	2042.0	29.5	85.4	6432.9
1956	2287.3	204.5	1581.5	2466.8	30.6	87.8	6658.5
1957	1987.7	206.5	1528.6	2524.4	26.3	73.7	6347.2
1958	2258.3	258.8	1654.7	2899.0	47.2	70.6	7188.6

1 In 1938-39, cattle and calf food combined, 2,132,700 long tons ; pig and poultry food combined, 1,756,600 long tons

POTENTIALS OF FEED UTILIZATION

We presume that this term of reference includes an estimate of the scope for increased consumption of feedstuffs in the United Kingdom. It has to be examined in the light of government policy which is directed, *inter alia*, towards a greater reliance on home-produced feedstuffs and a consequent reduction in our import bill for feedstuffs as a further contribution to our balance-of-payments position. Although we are producing more home-grown grain than in prewar days our imports over the last few years have been on average a little over 5 million long tons a year.

We are maintaining a larger livestock population than in prewar days and the following table shows the position in June 1939 compared with the provisional figures for June 1958 :

	June 1939 Thousand	*June 1958 (provisional) Thousand*
Total cattle and calves	8,872	10,973
Total sheep and lambs	26,887	26,174
Total pigs	4,394	6,517
Total poultry	74,357	100,075

The determination of guarantees in Command Paper 696—Annual Review and Determination of Guarantees 1959—suggests that there will not be any material increase in feed consumption during 1959-60 or in later years. It also seems that our production of home-grown grains, subject to normal and average weather conditions, will be of about the same volume in 1959-60 as in 1958-59. It therefore appears that our imports, as far as can be foreseen at this stage, will be about 5 million long tons. Moreover, a recent Government report on grass utilization and the recommendations thereof should stimulate the better production and utilization of grass and help to reduce costs and secure economies of imports of feedstuffs in the future. We may be approaching the limit of consumption of liquid milk and eggs, but there is scope for more red meat, much of which can be produced from grassland products. Possibly there is room for some expansion in feed consumption if the broiler industry continues to expand, but views are divided on whether broiler production will continue to expand at its present rate. This expansion opens up the possibility of increased consumption of coarse grain from imported sources.

At present, however, it is a fair statement that our manufacturers produce excellent compounded rations for all classes of livestock from raw materials freely obtainable on the world's markets and from the materials which suit the conditions in this country. These rations give very satisfactory performances in terms of levels of production and of good conversion ratios. It is therefore difficult to believe that they would wish materially to change their present basis of ration formulation unless there was clearly some considerable economic advantage in so doing. They are already very familiar with the structure of the U. S. feed manufacturing industry.

MAJOR MARKETING AND TECHNOLOGICAL PROBLEMS

One outstanding problem in Great Britain is the orderly marketing of home-grown grains. Each year so far compounders have given the Ministry of Agriculture, Fisheries and Food an undertaking to use home-grown barley as far as practicable in preference to imported barley, provided that the price is in line with world market values, that there is reasonable continuity of supply and that the quality is satisfactory.

At present, home production of barley is a little more than 3 million long tons a year compared with less than 700,000 long tons in prewar days. Moreover, owing to increased mechanization and better use of fertilizers the crop is produced at relatively lower cost on a much wider scale than before the war, sometimes at the expense of oats. Barley has established itself as a main carbohydrate feed for most classes of stock. Obviously the compound feed industry is by far the largest single customer for home-grown barley, and any large-scale switch over from barley to maize and sorghum would be detrimental to the interests of British agriculture and to our economy.

Barley, wheat, oats and rye are crops for which guaranteed prices are paid to farmers under the Deficiency Payments Scheme. Roughly, about 25 percent of the raw materials used in compounds are home-grown, principally barley. In addition, compounders use about 1-3/4 million long tons of oilcakes and meals, and wheat offals, manufactured in this country from oilseeds and wheat, respectively. In order that farmers may have an indication of what would be a reasonable price to accept for their barley, a Barley Working Party, comprising representatives of the National Farmers Union, the National Association of Corn and Agricultural Merchants, and the Compound Animal Feeding Stuffs Manufacturers National Association, provides farmers with a free market inteligence service for home-grown barley. Guide prices up to 3 months ahead, calculated on the basis of the price asked for imported barley for arrival during the same period, are announced weekly.

As far as imports are concerned, our importers have a free hand to obtain supplies to meet the demand of the feedstuffs industry. All the basic feedstuffs that cannot be met from home supplies are on World Open General License, and our importers obtain their supplies from various world sources at very keen competitive prices. About 50 percent of our total imports are from Commonwealth sources, all being admitted duty-free.

Maize and maize meal account for over half of our total imports of cereal grains. The United States has been our principal source of supply in recent years but this situation could alter at any time. Argentina apparently has one of the best crops harvested since prewar days, and even after its domestic needs have been met, it will probably have an exceedingly large surplus for export. Provided its prices are not out of line with those of other exporting countries, it could once again develop a very large trade with the United Kingdom. Apparently Argentina's type maize of small, hard, round reddish-colored corn is well liked by our compounders for poultry rations.

The Balkan countries—Rumania, Hungary, and Bulgaria—are very anxious to increase their exports of maize to the United Kingdom, and there is also the

possibility that Russia may enter the field in the near future. It appears that of late our importers have had reason to complain of the quality of maize from the United States, and hence, if they can get better quality maize from other sources at competitive prices they will not be slow to take advantage of the opportunity. Maize (other than white maize, which is not used by the feedstuffs industry) is admitted to the United Kingdom free of duty from any source.

The compound feedstuffs industry in the United Kingdom is well organized and its interests are looked after by the Compound Animal Feeding Stuffs Manufacturers National Association. Compounders sell their products at competitive prices, their marketing arrangements are keen, and every effort is made to keep costs to the farmer as low as possible.

Most of the largest port compounders run their own research establishments and experimental and demonstration farms, where they conduct longterm feeding trials on all classes of livestock. They employ scientific personnel of the highest caliber, who keep abreast of all current nutritional developments.

At one time there was a legitimate cause for belief that the compound feedstuff industry was very slow to adopt new ideas and to translate scientific advances into commercial practice. This phase has long since passed, and in the highly competitive conditions of today no firm can afford to be tardy in the application of new knowledge and developments. Indeed, the passing of the Fertilizer and Feeding Stuffs Act in 1926 may be taken as the turning point which served to establish confidence in compound feeds. Many modern mills have applied methods of automation, reducing considerably the risk of personal errors of judgment in formulation. Most large firms run a very efficient advisory service for their clients, who are kept well-informed of recent advances and developments. They also run well-equipped analytical laboratories for the routine control of the quality of the raw materials used and for the finished products, and the scientific work of their research units is well directed and organized and efficiently carried out. They maintain close contacts with the Universities, Colleges and Research Institutes of their-country, and their relationships with Government and other official bodies are always friendly and conducted in the happiest spirit of cooperation.

The smaller country compounders, though unable to maintain individual analytical and research establishments, are members of their own association, and they, too, have a ready source of advice and analytical service through their official Consultant and Analyst. The concentrate manufacturers also run their own research and experimental stations, and offer a valuable advisory and analytical service to their clients.

It can, therefore, be said that the compound industry in the United

Kingdom in its various facets keeps fully abreast of all nutritional and technological advances in livestock feeding, and that by their products and their services to the farmer they make an extremely valuable contribution to the agricultural community.

LEGISLATIVE REGULATIONS FOR FEEDSTUFFS [1]

Sources of Current Regulations.—The Fertilizers and Feeding Stuffs Act.15 December 1926.—16 and 17 Geo. 5, Ch. 45 (1926) ;

The Fertilizers and Feeding Stuffs Regulations 1955 and 1956—Statutory Instruments, No. 1673 of 1955 and No. 1853 of 1956 ;

The Therapeutic Substances (Supply of Antibiotics for Agricultural Purposes) Regulations, 1953 and 1954.—S. I. No. 1174 of 1953 and No. 1647 of 1954 respectively.

General Law of Fraud.—In the United Kingdom the Merchandise Marks Acts, 1887-1953 contains provisions for the repression of fraud in trade as a whole. However, in the field of animal feeds it plays a secondary role only, and its provisions on repression of fraud apply, in effect, only in cases not covered by the specific legislation constituted at present (see above) by the Act of 1926 and its Regulations of 1955 and 1956.

Special regulations affecting feeds.—It is thus largely these 2 latter texts, affecting both feeds and fertilizers, which contain the legislation governing the products here considered ; they also concern both simple and compound feeds.

Only the 2 other texts indicated above, i. e., the Regulations of 1953 and 1954 concerning antibiotics, affect animal feeds alone, considered apart from fertilizers.

Definition of feeds.—There is no express difinition of animal feeds in the Act of 1926 which describes such products as "food for cattle or poultry." "Cattle" is defined as meaning "bulls, cows, oxen, heifers, calves, sheep, goats and swine."

The Act relates to cattle or poultry feeds as such, and no provision is made for therapeutic substances and medicinal additives.

---

1 Largely taken from *Animal Feedstuffs : Regulations governing their Manufacture and Sale in European Countries*, F. A. O. Legislative Series No. 1, Rome 1957.

Licensing and registration.—United Kingdom legislation does not require manufacturers of, and traders in, animal feeds to obtain a license, or to register their articles, and, in a general manner, imposes no restriction on the manufacture and sale of feeds.

Rules governing names and labeling.—The products to which the provisions of the Act are applicable are governed by the first 4 Schedules to the Act of 1926 as amended by the Regulations of 1955. These Schedules constitute an integral part of the Act, the provisions of which are based on the same principle as that underlying the legislations of other European countries : The farmer has the right to be provided by the vendor with clear information as to the nature and composition of the products offered to him under many different names for feeding his livestock.

The first Sehedule contains a list of the principal feedstuffs in general use and prescribes in each case the particulars of composition of the product which vendors are required to furnish to purchasers ; for example, for a compound feed, the required particulars are :

(1) The name under which the article is sold.

(2) The content, if any, in fat, protein and fiber, respectively, expressed as percentages of the whole bulk.

(3) The presence of any of the substances included in the Third Schedule to the Act.

These particulars must appear, or must be indicated by a symbol mark, on the products or on their containers. If indicated by a symbol mark, it must be immediately intelligible and for this purpose the vendor must keep a register showing the full particulars indicated by the mark, and provide the purchaser, on or before delivery, or as soon as reasonably practicable thereafter, with a written statement containing those particulars.

The Second Schedule lists certain products which are regarded as variable in composition. Similar particulars of composition as in the First Schedule are required to be given to the purchaser in respect of these articles, but the particulars may appear in a written statement only, marking on the articles or on the containers not being required.

The Third Schedule concerns substances such as husks, chaff, and sawdust, the presence of which in the feed must be declared.

The Fourth Schedule gives definitions of the names of the feeds which have come within the scope of the Act. If any article is sold by a name included in the Schedule, this automatically constitutes a warranty by the vendor that the

article conforms to the definition in the Schedule.

It should be noted that with feeds affected by the First and Second Schedules, the requirement to give a written statement of the prescribed particulars does not apply to products constituted by mixtures made at the request of the purchaser, or to sales of small quantities (56 pounds or less), which are taken in the presence of the purchaser from a parcel bearing a conspicuous label containing the prescribed particulars.

Standards of composition.—Provided that the purchaser is given precise information on the subject, the manufacturer of animal feeds is free to fix the composition of his products as he pleases.

Exceptionally, minimum amounts of useful ingredients and maximum permitted amounts of useful ingredients and maximum permitted amounts of salt or fiber are included in the definitions of certain feeds named in the Fourth Schedule.

Furthermore, it is an offense for feeds to contain certain harmful ingredients, listed in the Fifth Schedule, which declares them to be deleterious to cattle or poultry.

Enforcement.—The enforcement of the Act of 1926 and of the Regulations is entrusted to certain local authorities, who are required to appoint inspectors, official samplers and official analysts. These appointments are subject to the approval of the Minister of Agriculture, Fisheries and Food, who may himself, in certain circumstances, directly appoint inspectors.

Inspectors are empowered to enter premises where feeds are exposed for sale and consignment, and to take samples for the purpose of checking that the statutory particulars being declared are correct. Official samplers, however, can only take samples at the purchaser's request when the purchaser, after delivery of the goods to him, wishes to avail himself of his facilities under the Act to have a sample taken and analyzed for the purpose of verifying the particulars given by his supplier. The purchaser is then called upon to hand over to the sampler the written statement furnished by the vendor, or a copy thereof. The official analysts issue to purchasers at whose request sampling was undertaken, certificates of analysis having the value official documents.

The inspection of registers at the premises of persons concerned and of statutory statements made by the vendor are regulated in detail by the County and Borough Councils in accordance with the financial terms established particularly by Article 17 of the Act.

Methods of sampling are described in detail in the Regulations, which also

prescribe the methods of analysis to be used and lay down the permissible limits of variation between content as declared and content as determined by analysis. However, among the various provisions of the Regulations, no rule is made regarding the number of check analysis to be made annually; decisions in this connection are left to the discretion of the local authorities administering the Act, having regard to their local knowledge and the reputations of the traders operating in their area.

Certificates of analysis issued by official analysts constitute legal evidence, but the person prosecuted is entitled to call this analyst as a witness or to request a further analysis by the Government Chemist, who may himself be called as a witness.

Finally, there is in the United Kingdom no voluntary system of control by the Trade.

Special active ingredients :—The Act of 1926 and its Regulations make no Specific provision for the addition to animal or poultry feeds of antibiotics, vitamins, coccidiostats or other chemical or pharmaceutical substances. But Section 7 of the Act provides that, subject to certain provisions :

> "Any person who sells or offers or exposes for sale for use as food for cattle or poultry any article which contains any ingredient deleterious to cattle or poultry, or has in his possession, packed and prepared for sale for such use any such article, shall be guilty of an offence against this act."

Other provisions concerning the use of antibiotics in animal feedstuffs are to be found at the end of this section.

Penalties—The statutory statement by the vendor containing the prescribed particulars has effect as a warranty that the particulars are correct within the limits of variation tolerated : if the particulars in the statement prove to be incorrect, the purchaser can take action against his supplier by recourse to a Civil Court of Law. In these cases, only the purchaser can take proceedings and no provision is made for recourse by the authorities to criminal proceedings. The title of the first relevant Section of the Act : "Civil Liabilities" is a sufficient explanation.

This warranty by the vendor, when thus applying to the products included in the First and Second Schedules to the Act, implies that the feed is suitable to be used for the purpose stated and that it does not, except as otherwise expressly stated in the statutory statement, include any ingredient included in the Third Schedule. In other words, when an article is sold by a name included in the Fourth Schedule, the vendor's warranty guarantees that the product accords with the definition thereof in that Schedule. Any statement as to the amount

of chemical or other ingredients, other than the praticulars required in the statutory statement, also has effect as a warranty that the facts stated are correct.

The purchaser may also claim *compensation* from his supplier in certain circumstances, when it can be proved the presence of deleterious ingredients in feeds has caused the illness or death of the livestock to which they have been administered.

Criminal liabilities are covered by Sections 4 *et seq.* of the Act : persons contravening the provisions of these sections are liable to fines up to 50 pounds and, for certain serious offenses, to imprisonment up to 6 months. Thus, the marking of incorrect statements on products included in the First Schedule or on their packaging, or stocking for sale products thus marked, renders the offender liable to penalties. Similarly, Section 7 imposes penalties on the vendor of a product containing deleterious ingredients unless he proves his good faith. He must show that he took all relevant precautions to avoid selling a product of this nature and that he was the victim of circumstances beyond his control.

As a general rule, local authorities can only take legal proceedings with the consent of the Minister of Agriculture, Fisheries and Food.

Future regulations.—No major change in the 1955 Regulations is expected in the near future. The Standing Advisory Committee set up under the Act is, however, reviewing the prescribed methods of analysis in the light of recent scientific research and may, from time to time, recommend that the Regulations should be altered to include more up-to-date methods. A start in this direction has, in fact, been made by the 1956 Regulations which prescribe a new method for the determination of phosphoric acid (P_2O_5) which can be used as an alternative to the method described in the 1955 Regulations. The Schedules to the Act can be varied by Regulations after consultation with the Advisory Committee, as was in fact done under the 1955 Regulations, in respect of the addition to fertilizers and feeds of substances having come into general use in manufacture since the previous Regulations were made.

Special provisions on the use of antibiotics in animal feeds.—Restrictions on the use of antibiotics were introduced by the Penicillin Act, 1947, and several years passed before the Therapeutic Substances (Prevention of Misuse) Act, 1953 (1 and 2 Eliz. II Ch. 32) gave power to make regulations to relax the restrictions. At present, the terms of the Therapeutic Substances (Supply of Antibiotics for Agricultural Purposes) Regulations, 1953 and 1954 (cited at the head of this section) made under the Therapeutic Substances Act, referred to above and now in force under the Therapeutic Substances Act, 1956, legalize and regulate the sale or supply of penicillin, aureomycin and oxytetracycline for mixing with feeds

for pigs other than breeding stock and for table poultry and supplements for mixing with these feeds.

The Regulations provide that a container of feeds, or of supplements, containing antibiotics shall have affixed to it or inserted in it a label giving certain particulars as required by the Minister. These include, for feeds, for example :

(1) The recommended minimum number of units of aureomycin, penicillin or oxytetracycline added per ton for each kind of feedstuff and the quantity so added expressed in terms of the equivalent of procaine benzylpenicillin, aureomycin hydrochloride and oxytetracycline hydrochloride, respectively ;

(2) The manner of preservation and the use of the feed.

The label for containers of supplements containing antibiotics requires certain additional particulars.

The Regulations further prescribe that feedstuffs containing antibiotics shall not contain a greater quantity of aureomycin, of oxytetracycline or of penicillin than the equivalent of one part of aureomycin hydrochloride, oxytetracycline hydrochloride or procaine benzylpenicillin, as the case may be, in 10,000 parts of the feedstuff.

Aureomycin supplement, oxytetracycline supplement and penicillin supplement intended for addition to feedstuffs shall not contain a greater quantity of aureomycin, oxytetracyline or penicillin than the equivalent of 1 part aureomycin hydrochloride or oxytetracycline hydrochloride or procaine benzylpenicillin in 90 parts of supplement.

TECHNOLOGICAL ADVANCES IN LIVESTOCK FEEDING

Calves

The "early-weaning" system.—An important advance in calf nutrition has been the development of the so-called "early-weaning" system. Traditionally, calves are reared on whole milk either by natural suckling or by bucket feeding, or on liquid milk substitutes for periods of 8-12 weeks, during which some dry concentrated food is gradually introduced. In the "early-weaning" system calves are weaned abruptly and completely at 3-5 weeks of age from whole milk or milk substitute onto a solid diet, which saves the time and labor associated with preparing and feeding mik substitutes. Furthermore, as the system requires the feeding of as little as 100 pounds of whole milk to each calf, the farmer has more milk for direct sale. The composition of suitable diets for early-weaned calves

has been derived from empirical feeding trials, for success depends primarily on the palatability of the ration. A proportion of animal-protein foods is generally used in these diets, but little is known about the exact protein requirement of the calf. For young stock, there is a general tendency to use lower levels of protein than were formerly considered necessary.

The use of pasture for young calves.—Increasing attention in research stations has also been given to the outdoor rearing of both spring—and autumn-born calves with particular reference to the use of good-quality pasture for the former and of foggage and silage during the winter for the latter, with the intention of accustoming the calves to such foods at an early age.

Milk substitutes —Owing to the extensive use of milk substitutes directly after the colostrum-feeding period and to the desire of some farmers to devise their own formulae, studies have been made on the efficiency of the utilization of various carbohydrates by calves, particularly in relation to the age at which enzymic activities in the gut are reasonably well developed. In the first month of life, the calf appears able to utilize efficiently only glucose and lactose. Starch utilization seems to begin effectively only with the initiation of rumen function and the full establishment of the rumen flora; ruminants appear to be poorly equipped to digest starch in the intestine.

Antibiotics.—Experiments have confirmed the classic finding of Theobald Smith that the protective action of colostrum lies in its immunological properties but do not support the view of some later workers that it may be due to its high content of certain vitamins. Tetracycline antibiotics (125-250 mg. daily per calf) have been found to be efficient substitutes for the dam's colostrum in protecting calves from *Escherichia coli* infection. They (about 8 mg. per pound feed) have also been used experimentally to increase the appetite of early-weaned calves, but the inclusion of such additives is proprietary calf foods in officially prohibited.

Dairy Cows

Pattern of feeding.—In the United Kingdom dairy cattle are normally fed mainly on grass during the period of about April to October and on stall rations consisting of hay, kale, silage, mangolds or swedes, and concentrated feeds during the remaining months. In some areas industrial byproducts such as beet pulp or brewer's grains are important sources of nutrients.

Recent advances.—In the planning of rations and control of quantities the traditional feeding standards for dairy cows, based on Starch Equivalent and Protein Equivalent (digestible crude protein plus digestible true protein divided by 2), are still used in the United Kingdom, although with less confidence than before the war. It is partly because newer knowledge of rumen function has

emphasized their basic defects and partly because the greater use of grass and grass products has inevitably reduced precision in feeding.

There is a fairly widespread belief that the standards for Starch Equivalent requirement for milk production may be too low, and in the opinion of some authorities they should be increased by 10 percent to bring them more nearly into line with the energy standards in other countries. On the other hand, the protein standards for milk production have probably been generous and the recommended standard of 0.6 pound of Protein Equivalent has been reduced to 0.5 pound by some authorities.

The lack of accuracy of current feeding standards in relation to ruminant nutrition is becoming very obvious to the rumen biochemist, but it is difficult to forecast the stage at which the newer knowledge of rumen function can be applied to practical feeding. It seems clear that some interesting advances in this direction might take place in the next few years. The approach to the problem of the biological value of protein for the dairy cow may, in future, have to take account of the rate of ammonia release in the rumen which varies not only with the individual food, but also in relation to the other food used. Similarly, carbohydrate digestion and metabolism through the fatty acids in the rumen is now appreciated as a problem quite different from that in monogastric digestion and the inferences so far as the synthesis of fat and non-fatty solids are concerned are partially understood.

The low-fiber diets occasionally involved during winter and, more often, in grazing young leafy grass in spring are not infrequently associated with milk of a low butterfat content, and measures are taken to check this difficulty by increased feeding of roughage. Similarly, the association between milk of a low protein content and a low plane of nutrition in the dairy cow is recognized as a practical problem which can sometimes be rectified by raising the plane of nutrition. There is, however, little evidence so far of attempts to regulate by nutritional means the production of rumen ammonia or of particular integrations of fatty acids, except in experimental trials.

It seems likely that efforts in this direction will intensify in the United Kingdom, partly because the producer of milk of low compositional quality is being penalized financially, and any control of milk quality that can be brought about by feeding will be of considerable economic importance.

In addition, however, the relationship between rumen function and health is gradually becoming evident. For example, in the United Kingdom the incidence of hypomagnesemia has greatly increased. In dairy cows the condition frequently passes into the acute clinical phase when cattle are turned out to grass in the spring. The condition at this time may be controlled by feeding

with magnesium (say 2 ounces MgO daily), given by drenching, feeding in a concentrate mixture, or in minerals, and partial control may be effected by raising the magnesium content of the sward by applications to the soil of fertilizers containing magnesium. Elucidation of the basic causes of the dramatic fall in blood-magnesium levels when cows go to grass would not only help to solve an important practical problem, but might also add to the knowledge of rumen function.

Many papers have appeared in the United Kingdom in recent years concerning the milk yield response to differing levels of feeding. This matter is of considerable economic importance, because during the winter when 1 gallon (4.5 litres) of milk may be worth 3s. 6d., the 2½ pounds of Starch Equivalent required (by the feeding standards) to produce it may cost ls. Od. Since nearly half of the cattle population is now of Friesian type and many of the remainder of other dairy breeds, there is normally a great genetic potential for much higher yields, and even when food is used less efficiently, it may be economically sound to feed at levels higher than the feeding standards. At the same time Starch Equivalent is often available at a much lower cost in the form of home-produced bulky foods which, however, can be eaten only in restricted quantities. As a result there is much, controversy as to the relative merits of a low-cost/low energy intake resulting in moderate yields or of a higher-cost/high-energy intake resulting in higher yields. A notable feature of experiments which seek to throw light on the problem of response in milk yield to differing levels of energy input is that short-term experiments lasting only a few weeks indicate a response of a low order to changes above or below the standards compared with greater responses to varying planes applied to whole lactations. Evidence is also accumulating that increase in the level of feeding either before or immediately after parturition is much more effective than increases in mid or late lactation so for as to tolal lactation yield is concerned.

One important problem of national milk production is the need for better and more efficient utilization of grassland. With improved strains of grasses and legumes, more adequate fertilizing of pastures, better methods of grazing control, improved techniques of grass conservation as hay and silage, it is evident that grass, properly utilized, could make a much greater contribution to the needs and requirements of dairy cows than it does at present. Indeed, it is a part of official policy to encourage the maximum utilization of grassland and its conserved produce to help reduce the heavy import bill for concentrated feedstuffs.

The majority of farmers supplement the grazing of dairy cattle with some concentrate feeding. Many experiments indicate that, with adequate good-quality grass, added concentrates are likely to be uneconomic. It seems, therefore, that the grass or method of its utilization on commercial farms is still open to im-

provement or alternatively that there is a tendency to feed unnecessary concentrates. The early part of the grazing season is, however, an exception, since supplementary feeding at this time often brings exceptional advantages. These include protection against hypomagnesemia and bloat, prevention of low butterfat content in the milk, control of scouring, and reduction in indigestion due to a sudden change of diet.

Control of grazing by daily strip folding is used extensively, although recent experiments indicate that daily folding *per se* has little advantage over rotational on, say, a weekly basis, although the higher stocking rate which is often involved in strip folding may substantially increase milk output per acre.

Mineral imbalance.—In the United Kingdom problems arising from mineral deficiencies and excesses, and also those concerned with so-called metabolic disorders are spasmodic rather than general in occurrence. Apart from occasional general shortage of calcium and phosphorus the main trace-element deficiencies are of copper and cobalt which fortunately are mainly associated with areas where dairying is of minor importance. The 2 troublesome mineral excesses are of molybdenum, associated with a particular soil formation, mainly in Somerset, and fluorosis, which is almost entirely associated with certain industrial areas.

Deficiency of copper and excess of molybdenum are both dealt with by the addition of copper sulphate to concentrated feedstuffs, the aim being to provide 2 grams of copper sulphate per cow per day.

Milk yield.—There has been in the United Kingdem a revolutionary change in cattle numbers, in that during a period of 2 decades the traditional dual-purpose animal has been replaced to a great extent by single-purpose dairy cattle particularly of the Friesian, Ayrshire, and Channel Island breeds. This switch has been made possible by extensive use of artificial insemination ; at present about 60 percent of the dairy cattle are inseminated. It has resulted in cattle capable of much higher milk yields, and there has been a steady trend towards a higher level of nutrition aimed at realizing some of this potential. As a result the mean sales per head for all dairy cattle in England and Wales have been increased from 4,720 pounds in 1942-43 to 7,450 pounds in 1957-58.

Beef cattle

With changes in public taste and the demand for smaller and leaner joints, beef animals are slaughtered at a younger age when their live weights are lower and they are generally less mature. In consequence, such animals today do not undergo the old type of store period, in which they subsisted on low-quality roughage and bulky foods and made very small live-weight gains, and which was followed by very liberal feeding on concentrated foods.

Modern requirements demand that beef animals should gain at a more or less steady rate throughout their relatively shorter lives. After the calfhood phase has passed (i.e., the first 6 months of age) growth is accomplished on grass or on good-quality forage crops or conserved foods such as silage, and the final stages of fattening are completed by a liberal use of cereals and beet pulp, with a minimum of protein foods. Consequently there has been rather limited scope for manufactured compound feeds for beef cattle.

The discovery that synthetic estrogens such as stilbestrol and hexestrol are of value in accelerating the rate of live-weight increase in the final stages of fattening has given some new impetus to the use of compound feeds, for the small amounts of estrogen require a very thorough and uniform blending with the food. With home-mixed rations implantation is often more convenient. Hexestrol is preferred because the 'side-effects' of its use are less than those of a corresponding level of stilbestrol. Because of the possibilities of misuse of hormone-containing rations and of a build-up of estrogens in the soil through the excreta, an official warning has been given of the dangers, but no legislative powers exist at present to prevent manufacturers from adding hormones to specific rations, if they so desire.

More information is needed on the requirement of fattening cattle for digestible protein and allowances now recommended in the United Kingdon are possibly too high. Over the past few years considerable attention has been given to planes and patterns of feeding (high and moderate) in an endeavor to determine the most economic system of feeding. Much of the beef in the United Kingdom is obtained as a byproduct of the dairy industry and in this connection the Friesian breed has assumed a new importance. Patterns of feeding need to be more closely integrated with breed structure.

Pigs

Pattern of feeding.—In the United Kingdom pigs are kept under a great variety of conditions and in units varying from very small to very large. There are 15 recognized breeds but only 4 or 5 are of major importance with the Large White and Landrace predominating. Pigs are usually fed on rations consisting of cereals (mainly barley meal, wheat, and wheat offals) with protein supplements. Occassionally bulky feeds such as swill, potatoes, and fodderbeet are used.

Research in progress.—The Adviser on Pig Research to the Agricultural Research Council produces annually an index of current research on pigs covering all research activities in the United Kingdom. An interesting development in recent years has been the organization by the Adviser of coordinated experiments at 20 to 30 centers to investigate day-to-day problems of the industry under practical conditions of pig husbandry.

Developments in breeding.—The last decade has seen considerable reduction in the fatness of British pig carcasses, mainly stimulated by a system of quality premiums for baconers sold on their dead weights and grades. To assist in maintaining continued genetic improvement national litter-recording and progeny-testing schemes have been instituted. Discussions continue, however, on the relative merits of the "progeny test" and the "boar test" and of a combination of both.

One large research institute is studying heterosis in pigs and the possibilities of genetic improvement through the crossing of selected inbred lines. Another major project is one in which a measured amount of selection is made for a specified characteristic in a normal population and the amount of improvement attained and the effects on other important characteristics are measured.

Housing and management.—The knowledge of the import of housing and management is still very meager but attention is now being focused on problems of effect of environment (temperature, humidity, light) on productivity.

Developments in marketing.—The 3 main outlets for pig meat are the bacon, pork, and manufacturing trades. The requirements for bacon are specified at about 180-210 pounds live weight. There is controversy on the requirments of the other 2 trades. The prewar 100-pound porker has now become a luxury article. The tendency is to use for fresh meat pigs in the bacon range or slightly below, and heavier pigs, up to 270 pounds, and discarded breeding stock for the manufacturing trade.

One large manufacturing firm now chooses "heavy pigs" for the production of bacon from bellies and trimmed backs. All trades want a well-fleshed pig with little fat, although the manufacturing trade at present accepts a higher proportion of fat, which is trimmed and rendered into lard. Pigs can be sold by the producer on either their dead weights and grades on either their dead weights alone (only to one company) or by auction. Many farmers consider that one of the greatest problems of pig production is the need for reorganized marketing systems.

Developments in nutrition.—1. Daily feed intakes.—Since the 1930's there has been considerable interest in the effects of varying the plane of feeding upon food-conversion efficiency and carcass quality in baconers. At present most pigs are hand-fed to a restricted scale, which in comparison with self-feeding gives better food-conversion efficiency and leaner carcasses.

2. **Protein quantity and quality.**—The last war stimulated the reevaluation of protein requirements and the use of vegetable proteins as replacements for white

fish meal, which is home produced and of high feeding value but expensive and sometimes scarce. In consequence, levels of protein have been reduced in many rations and increasing use has been made of peanut meal and soybean meal.

Cutting out excess protein from rations has underlined the need for careful evaluation of the protein quality of the high-protein foodstuffs used. Quality varies with source of protein and efficiency of processing, and different samples of the same foodstuff may differ in value in a way not shown in routine analysis. Thus new chemical methods of assessing protein quality are being investigated and are the subject of a large-scale experiment coordinated by the Agricultural Research Council.

3. **Amino acid supplements** —As methionine and lysine become cheaper, it will become economically possible to include them in practical pig rations. Experiments are in progress to test the value of these amino acids as supplements to cereals and to vegetable-protein foodstuffs.

4. **Fat.**—Fats are not added to pig rations, except perhaps to a few meal mixtures fed to pigs weaned at 2-20 days old. There is little incentive to produce extra-high-energy rations because of the need to restrict energy intake to produce high-quality carcasses.

5. **Antibiotics.**—The growth response to antibiotics varies from farm to farm but average increases of 10 percent in growth rate and 5 percent in food-conversion efficiency are obtained between weaning and bacon weight. Although it is permissible to sell rations containing antibiotics for pigs other than breeding stock, the demand appears to be limited and most compounded pig rations (at a guess 75 percent) are sold with no antibiotic added. Some farmers mixing their own rations add to them an antibiotic supplement. Research and discussion continue on whether antibiotics will cause the emergence as a problem of antibiotic-resistant pathogenic bacteria. The antibiotics permitted as feed additives are chlortetracycline, oxytetracycline and procaine penicillin. The usual dose rate of the tetracyclines is 10 grams per long ton (2240 pounds) and that of penicillin is lower.

6. **Copper sulphate.**—Copper sulphate added as 0.1 percent of all-meal rations fed from weaning to bacon weight gives increases in growth rate and food-conversion efficiency about equivalent to those from antibiotics. Some compounders are adding 0.05-0.1 percent copper sulphate to some of their feeds for baconers, but the extent of this practice is not known.

Investigations are proceeding on the optimum level of copper-sulphate inclusion, upon possible additive effects with antibiotics, upon feeding it to sows and upon its mode of action as a growth stimulant.

7. **Other growth stimulants.**--Experiments on feeding and implanting hormones and small-scale trials on feeding arsenicals have not given sufficiently promising results to warrant at present the recommendation of their use in practice.

8. **Zinc and parakeratosis.**—In some parts of Great Britain parakeratosis was a major problem usually associated with self-feeding. The discovery in the United States of the relationship between zinc, calcium and parakeratosis has led to the inclusion of zinc carbonate in most compounded rations at the rate of about 0.5 pound per long ton.

9. **Iron and anemia.**—British commercial firms have pioneered the use of iron-dextran injections to prevent and cure iron-deficiency anemia in those piglets having no acceess to soil. The injections are used extensively to cure anemia, but many farmers prefer the more laborious but considerably cheaper method of dosing with reduced iron or iron salts as a routine preventive measure.

10. **Stabilized vitamins A and D.**—Both compounders and farmers are tending to use "dry" stabilized vitamin A and D preparations rather than fishliver oils in their pig rations.

11. **Complex vitamin and mineral supplement.**—Several vitamin, trace-mineral, and vitamin plus trace-mineral supplements of varying complexity are marketed, but it is difficult to estimate the amounts used. It is probable, however, that riboflavin is included in some compound rations.

12. **Early weaning.**—Several commercial firms have marketed meal mixtures for feeding to pigs weaned at 7-14 days of age, and one has advocated weaning at 5 weeks and has compounded rations for this purpose. At first farmers who changed from 8-week weaning to 10-day weaning reported success with the new system. After early weaning had been practiced for some time in the same pens, however, the growth rates of the young pigs frequently deteriorated to such an extent that the system was abandoned and 8-week weaning was resumed. The breakdown in early weaning has almost certainly been caused by increases in disease level, and particularly in the incidence of scour. Disease level must be treated as one of the major problems of early weaning at the present time. There is also uncertainty about the effects of early weaning on the longterm performance of sows.

Further investigations are required on the fundamentals of the physiology and nutrition of young pigs. Work is progressing upon the development of the digestive enzyme system, the reaction of young pigs to changes in physical environment and on their nutritional requirements.

13. **The nutrition of sows.**—There is increasing interest in the nutritional requirements of sows during pregnancy and lactation. A few experiments are in progress on this very broad and important subject and preliminary results suggest that unnecessarily large amounts of protein and total food are frequently given to sows during pregnancy.

14. **The feeding of separated milk.**—The primary aim of British milk production is to satisfy the liquid milk market. In times of overproduction, however, surplus milk is manufactured into cheese and butter; thus whey, skim milk and dried skim milk are available for pigs. Experiments continue on the most effective ways of feeding these byproducts.

Formalin added at 0.1-0.2 percent of the skim milk in storage tanks has been shown to prevent spoilage and clotting and facilitate piping off. Such formalin-treated milk has proved nutritionally equivalent to fresh skim milk.

15. **Availability of nicotinic acid in cereals.**—Nicotinic acid is present in cereals in a bound form. Experiments have shown that pigs connot utilize the nicotinic acid of maize unless it is set free as, for example, by treatment with lime-water as in the making of *tortilla* bread in Mexico.

Poultry

Shape of the industry.—The outstanding development in poultry in the United Kingdom over the past 10 years has been the establishment of the broiler industry on a large and expanding scale. There has also been a considerable expansion in the numbers of turkeys.

These developments have proceeded along the lines of increasing intensivism and even with breeding stock intensive methods are rapidly gaining favor. The egg-producing industry has also undergone a marked change in the past 20 years. Whereas in 1939 most layers were kept in small flocks on range, the great majority is now housed intensively. The size of unit has tended to increase markedly, and most commercial egg producers use 3-tier laying batteries. This intensivism necessarily requires that diets shall be more and more complete in respect of every nutritional factor necessary for the welfare of poultry stock.

The broiler industry has now become highly organized as a business, and a most important consequence has been a vast increase in the manufacture of specialized poultry foods. The amount of nutritional research on poultry in the United Kingdom is low in relation to the size and importance of the industry, and manufacturers of compound foods have tended to rely, *faute de mieux,* on United States standards.

High-energy rations.—There has been considerable interest in the use of

high-energy rations, but with the high cost of fats in relation to cereals such rations are still based largely on best-quality cereals. There is considerable dissatisfaction with the present methods of estimation of the content of available energy in poultry rations. The inadequacy of "crude-fiber" and "nitrogen-free extractive" as measures is now recognized, and more useful methods of evaluating the carbohydrate fraction of the diet are being studied.

Antibiotics and other additives. – With the present emphasis on high performance rates, growth stimulants have assumed increasing importance. Antibiotics (penicillin, chlortetracycline and oxytetracycline) at low levels (5-10 grams per long ton) are now almost universally used in the rations of chicks and broilers, and for special purpose high levels (up to 100 grams per long ton) may be used.

One industrial firm has just completed an extensive experiment with laying birds showing that chlortetracycline at levals of 25-100 grams per long ton of feed brings about improvement in egg production, particularly in flocks of lower productivity. It is also common practice to include coccidiostats and drugs to control other diseases in many of the rations, and there is increasing interest in the use of synthetic amino acids. Synthetic vitamins A and D3 and riboflavin and vitamin B12 are now almost universally included. An interesting recent development is the increase in sales of concentrates which the farmer can mix with his own ground cereals to supply the protein, mineral and vitamin fractions of the ration.

Research is going on regarding vitamins A, D3, members of the vitamin B2 complex, and vitamin B12, and considerable work is being done to determine the nature of the so-called "unidentified growth factors."

Protein quality. – The collaborative work under the aegis of the Agricultural Research Council on the development of rapid chemical methods for assessment of protein quality has already been mentioned in the section on pigs. Should improvement in quality result from this work, it might lead to reduction in protein levels in the rations of pigs and poultry without any loss of efficiency thus further cheapening rations generally.

The finding that white fish meal can depress the hatchability of fertile eggs is being further studied, and attempts are being made to assess optimum levels of fish meal in the ration and the value of possible alternatives. An interesting practical observation now receiving confirmation is that growing pullets reared on oats and good pasture and then placed in cage laying batteries on a normal laying mash apparently produce more eggs and of higher quality than similar pullets reared on more conventional growers' rations.

Nutrition in relation to disease.—Work at one of the research stations has shown that a ground-wheat ration had a beneficial effect on the occurrence of fowl typhoid compared with more complex rations containing high levels of fish meal. Similarly in experimental Blackhead in chicks, mortality from the disease could be reduced by nearly 30 percent with exclusive grain feeding from its incidence on normal growers' rations and by a similar amount with 20 percent oat fiber added to the growers' ration. Addition to the diet of all required vitamins at high levels had no effect on the mortality or survival time of chicks artificially infected with fowl typhoid.

Genetics and breeding.—The operation of the Poultry Progeny Testing Scheme, enabling breeders to assess the efficiency of their own methods of selection will almost certainly result in a demand for advice on means of improving these methods. Vigorous research is going on in several centers on many aspects of breeding systems, including those of the exploitation of commercial hybrids, an important development within the poulty industry.

Sheep

Pattern of feeding.—Sheep production in the United Kingdom is almost entirely confined to outdoor production. Traditionally there are 2 main classes of stock, hill sheep and lowland flocks. The hill sheep are mainly confined to the north of England, Scotland, and Wales, often on poor upland farms where any other form of agriculture is impossible. Apart from the problem of when it is, or is not, economic to provide any supplementary feed, the technical problems have often been concerned with calcium and phosphorus supply and trace-element deficiencies. The lowland flocks include many which have traditionally been folded on arable crops often with the inclusion of roughly balanced concentrates. Labor costs in recent years, and improved grass production have encouraged more extensive handling of lowland flocks and greater dependence on grass.

Diseases of nutritional origin.—The main problem is copper defiiciency, causing swayback. The deficiency is not simple and may occur on pastures which on analysis appear to contain adequate copper. At present treatment is by drenching with copper sulphate during pregnancy, but less laborious methods are being developed.

Cobalt bullets are being used in cobalt-deficient areas and the calcium and phosphorus status of hill sheep is being investigated.

Genetics and physiology of reproduction.—Several tests are in progress on the performance of progeny from different breeds and crosses. Genetic variations in breed characteristics and in resistance to helminthic infestation are also being studied.

Success with transplantation of ova and the control of the ovulation with hormone treatment have been reported but these techniques are not yet sufficiently developed for practical application.

Management.—Most studies are concerned with the management of sheep on pasture and with the effects of various rates of stocking. There has been considerable interest in a 'side-ways creep' method of grazing lambs ahead of ewes. There has also been an increase in breeding from one-year old ewe lambs, particularly of the Clun Forest breed.

Ewe lambs on hill land are now frequently wintered 'at home' instead of being sent to the lowlands. They are fed on hay and have access to shelter sheds which sometimes have slatted floors.

Wool.—Attention has been paid to the measurement of fleece characteristics but only little to the effect of nutrition on fleece weight and quality. The effects of thyroxine on wool growth are being investigated.

Nutrition.—The fattening of store lambs on turnips is being replaced in the south by fattening on kale or rape. Grass silage is being used increasingly for feeding to in-lamb ewes.

There has been a considerable increase in the practice of feeding concentrate mixtures based on oats and protein cakes to hill sheep before lambing, which is said to produce stronger lambs and more milk.

In lowland flocks there is more emphasis on feeding concentrates late rather than early in pregnancy. A rising plane of nutrition protects from pregnancy. toxemia.

One research institute now recommends weaning orphan lambs at 3-4 weeks old on to stated meal mixtures, but no complete mixtures for this purpose are compounded commercially.

Experiments have been conducted on implanting hexestrol into young lambs, store lambs fattened during the winter, ewes for slaughter and ram lambs (in place of castration). The most promising practical application is for store lambs fattened on roots, kale or rape during the winter, provided feed supplies are liberal. The extent of the application of these findings by farmers is not known.

Experiments are in progress on feeding hexestrol in meal mixtures but no such mixtures are being marketed at present.